# Equilibrium Under the Action of Concurrent Forces

## Week 2, Lesson 1

- Concurrent Forces
- Equilibrium
- First Condition for Equilibrium
- Problem Solution method

References/Reading Preparation:
Schaum's Outline Ch. 2
Principles of Physics by Beuche – Ch.4

# Concurrent Forces

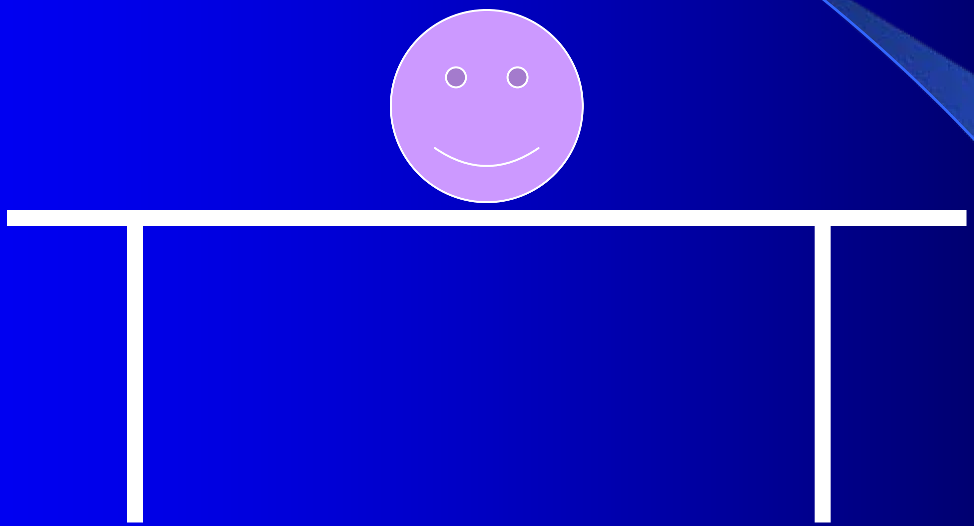
Concurrent Forces are forces whose line of action all pass through a common point.

The forces acting on a point are concurrent because they all pass through the same point – the point object.

# Equilibrium Under the Action of Concurrent Forces

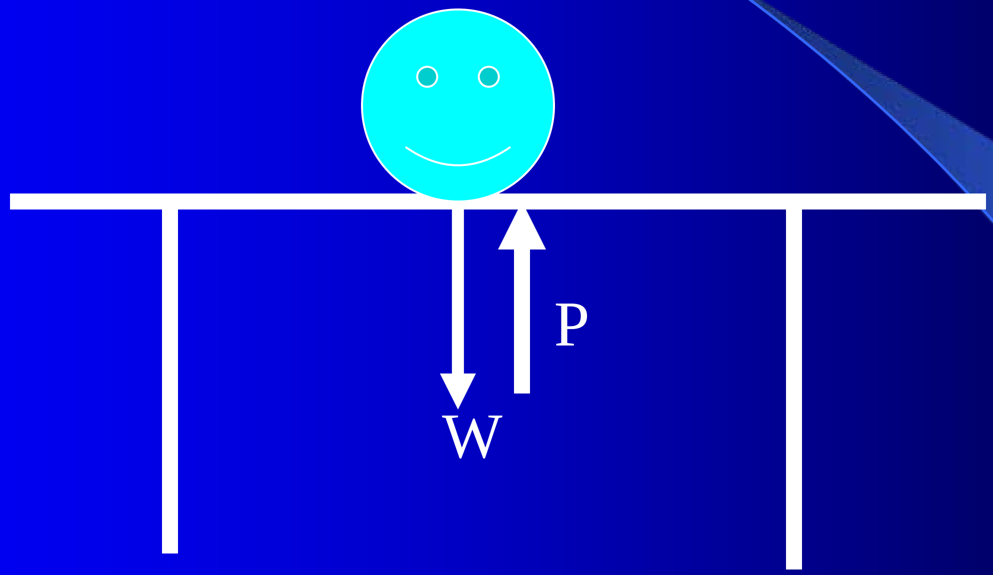
An object that is at rest and remains at rest is said to be in Static Equilibrium.

# Consider an object on a table



# What forces act on the object?

- We know that if we take the table away, the object will fall.
- This tells us that a force is pulling downward on it.
- This gravitational pull that the earth exerts on the object is called the "weight" of the object.




To support the object, the table must push upward on it.

The object will remain motionless (in static equilibrium) if W and P are equal in magnitude and in opposite directions.

# Equilibrium

- In this case, the vertical forces acting on the object must balance if equilibrium is to be achieved.

*In other words,*

*For an object to be in equilibrium, the vector sum of the forces acting on it must be zero.*

# Free-Body Diagram

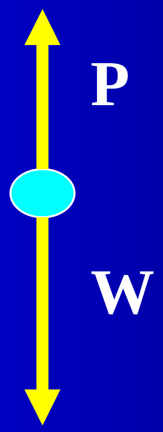
- In the analysis of objects in equilibrium, it is helpful to sketch a free-body diagram for the system.
- We represent the object with a dot and the forces with arrows.

# Free-Body Diagram

**P** represents the force exerted by the table on the object

The dot represents the object

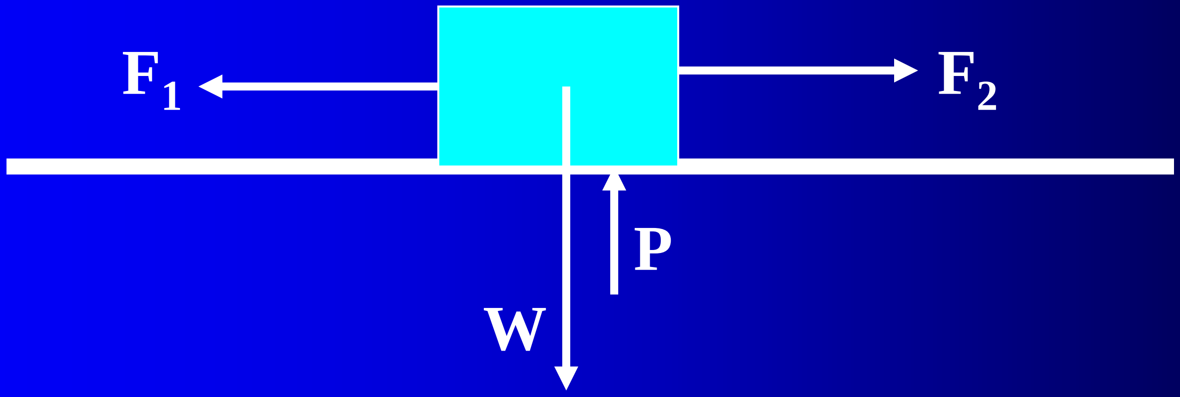
**W** represents the weight of the object – the force exerted by the object onto the table




*Note that both **W** and **P** are both vector quantities – they both have a magnitude and a direction.*

# Another example

- Consider the following:




There are four forces acting on the block

# The block example cont..

- For the block to remain in equilibrium, the vector sum of the vertical forces (**W** and **P**) must be zero; **and**

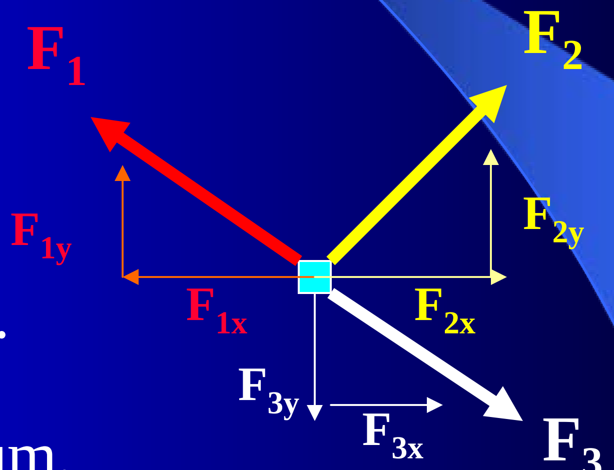
- The vector sum of the horizontal forces ($\mathbf{F_1}$ and $\mathbf{F_2}$) must be zero.

# We Conclude:

For an object to be in equilibrium, the vector sum of the forces acting on it must be zero.

# Consider the following:

- An object subjected to three forces.




Lets divide these forces into Their rectangular components.

For this object to be in equilibrium,

$\mathbf{F_{1x}} + \mathbf{F_{2x}} + \mathbf{F_{3x}} = 0$ (horizontal forces must equal zero)

$\mathbf{F_{1y}} + \mathbf{F_{2y}} + \mathbf{F_{3y}} = 0$ (vertical forces must equal zero)

# Conclusion

In the general case, the first condition for equilibrium can be written:

$\Sigma \mathbf{F_x} = 0$ (sum of the forces in the x-direction equals zero)

$\Sigma \mathbf{F_y} = 0$ (sum of the forces in the y-direction equals zero)

$\Sigma \mathbf{F_z} = 0$ (sum of the forces in the z-direction equals zero)

# SUMMARY

1. Concurrent Forces are forces whose line of action all pass through a common point.

2. An object is in equilibrium under concurrent forces if:
   a) it is at rest and remains at rest (static equilibrium);
   b) it is in motion with constant vector velocity.

3. The first condition for equilibrium is $\Sigma \mathbf{F} = 0$;
   in component form, $\Sigma F_x = \Sigma F_y = \Sigma F_z = 0$.
   That is, the resultant of all external forces acting on the object must be zero. (A second condition exists which we will learn in the next chapter.

# Problem Solution Method (Concurrent Method)

1. Isolate the object for discussion.

2. Show the forces acting on the isolated object in a diagram (the free-body diagram)

3. Find the rectangular components of each force.

4. Write the first condition for equilibrium in equation form.

5. Solve for the required quantities.

# Examples

- Lets do some examples on the board to illustrate further these concepts and what we have just learned.